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Life history of *Moina micrura* (KURZ) fed with three algae species, in the laboratory

by

José Gerley Díaz-Castro & Elsa Rodrigues Hardy

M.Sc. José Gerley Díaz-Castro & Dr. Elsa Rodrigues Hardy, Laboratório de Zooplâncton, Instituto Nacional de Pesquisas da Amazônia (INPA), Caixa Postal 478, 69011-970 Manaus, AM, Brazil.
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Abstract

The life history of *Moina micrura* (KURZ) was investigated under controlled laboratory conditions using the bottles rotated in wheels McCARTHY (1983), in constant temperature water baths (26 °C - 28 °C). The long-term growth experiments were performed using constant food concentration of three green algae: *Scenedesmus quadricauda* 12.5 x 10^7 cell/ml, *Ankistrodesmus gracilis* 8.33 x 10^7 cell/ml and *Pediastrum duplex* 7.1 x 10^7 cell/ml. Animals were examined daily throughout their life cycle from the neonate to their natural death for the following life history traits: individual growth, fertility, number of instars and longetivity. The one way ANOVA showed that, out of nine parameters evaluated, only one was signicantly different ($P < 0.05$). The three algae species were considered a suitable food for *Moina micrura*.

Keywords: ***Moina micrura*, Tropical, life cicle, food experiments.**

Resumo

A história de vida de *Moina micrura*, foi investigada em condições controladas de laboratório, usando o sistema de "rodas giratórias" (McCARTHY, 1983), imerso em tanque de água com temperatura constante (26 °C - 28 °C). Um indivíduo foi colocado em cada garrafa contendo água filtrada com alimento (algas) de concentração conhecida (1.0 mg C/L), que foram acopladas ás rodas giratórias. Os experimentos de crescimento foram realizados usando três espécies de algas: *Scenedesmus quadricauda* 12.5 x 10^7 cell/ml, *Ankistrodesmus gracilis* 8.33 x 10^7 cell/ml e *Pediastrum duplex* 7.1 x 10^7 cell/ml. Os animais foram examinados diariamente desde neonatas até a morte natural para estudar a história de vida: crescimento individual, fertilidade, número de estágios e longevidade. Os testes de ANOVA, mostraram que dos nove parâmetros investigados, somente um foi significativamente diferente ($P < 0.05$). Não houve diferenças consistentes nos oito parâmetros investigados em presençia de nunhuma espécie de alga, somente a produção média de ovos de *Moina micrura*, alimentada com *Scenedesmus quadricauda* foi menor e estatisticamente diferente quando comparada as médias de ovos produzidas pelas demais espécies. As três espécies de algas foram consideradas alimento de boa qualidade para o crescimento e o desenvolvimento de *Moina micrura*.

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Introduction

The quality as well as quantity of food is known to be an important factor controlling the growth and reproduction of zooplankton. According to the degree of digestion and the survival, reproduction and growth success or not of *Daphnia* reared with several different algae species. LEFEVRE (1942) qualified them as good, intermediate, or poor foods. Great differences were observed between closely related food species. ROCHA (1983) tested *Scenedesmus acutus* and *Monodus subterraneus* in the studies of three *Daphnias* and both proved to be a good quality foods. INFANTE & LITT (1985) offered 10 species of algae present in Lake Washington to *Daphnia pulicaria* and *D. thorata*. The best perfomance on growth, and reproduction were obtained with *Cryptomonas erosa*.

Compared with the temperate regions, life cycle studies of tropical cladocerans are still very few. Some studies are from Indian and African waterbodies (MURUGAN 1975; JANA & PAL 1985; BONOU et al. 1991; SAINT-JEAN & BONOU 1994), in those studies, mainly on the growth and development of *Moina* the autors fed their experimental animals using filtered natural pond water in which neither quality nor quantity was defined. Experiments under well defined food concentrations are scarce: JAYATUNGA (1986) has studied experimentally the life cycle characteristics of the Sri Lanka cladocerans, such *Moina micrura* and AMARASINGHE et al. (1997) studied the responses of Sri Lanka cladocerans and copepoda under well defined food quantity. ROCHA & MATSUMURA-TUNDISI (1990) found important differences on the response of the three species of tropical *Daphnia*, fed with known concentrations of *Scenedesmus bijugatus*.

For amazonian cladocerans, there is experimental information such as those of FIM (1992) using *Moina micrura* fed on organic and inorganic wastes as culture medium in a semi natural pond, and the work of HARDY & DUNCAN (1994) on a long-term growth experiments performed under controlled laboratory conditions of temperature, food concentration and turbidity on development time of *Daphnia gessneri* and *Moina reticulata*.

For this study, *Moina micrura* was choosen particulary, because is a regular cladoceran growing in a natural pond at the Aquaculture station of INPA being considered a very promising organism for aquaculture and system manipulations. FIM (1992) observed that *Moina micrura* can be cultivated with success and is well accepted as food by young of fish such as *Colossoma macropomum* and *Brycon cephalus*.

The aims of the work is to examined the performance of *Moina micrura* on a long-term growth experiments reared with three different species of algae, in order to better identify its potential in aquaculture and system manipulations.

Material and methods

Stock cultures

Moina micrura was collected from the pond of the Aquaculture station at INPA in Manaus and they were maintained in beakers, fed with filtered natural pond water for observation. The adult mature female were isolated and transferred to another beacker acclimated for at least one week, with food (natural pond water, adding algae). The algae were maintained in the exponential phase of growth using NPK in the proportion of 20:5:20.

Preparation of experimental food

Samples of each algae (50 ml) taken from the 5 to 6 day (exponential phase) old liquid samples were centrifuged and washed in distilled water to remove the nutrient medium. The organic carbon content of the algae were calculated according to the methodology proposed by PARSONS et al. (1989). The algae cell was done using the Neubauers camera (MARGALEF 1974). The number of algae cells were respectively, $12.5x10^7$, $8.33x10^7$ and $7.1x10^7$ for *S. quadricauda, A. gracilis*, and *P. duplex*. The food medium with a concentration of 1.0 mg C/L of algae was prepared by adding appropriate amount of sterilized natural water.

Experimental chamber

The life history experiments, were undertaken using the rotating bottles on wheels (McCARTHY 1983), constructed and adapted in the Zooplankton laboratory of INPA-Manaus. Ten, 150 ml plastic bottles, were attached to wheels, in this case, bicycle spokes, which turned the bottles around their long axes with the help of a low electric rotation motor. The wheels were kept in temperature controlled water tank of 280 liters capacity.

Each bottle, containing food level of 1.0 mg C/L of each alga had one single individual of *M. micrura.*

Experimental procedure

For each parameter involved in the life history of *Moina micrura*, a minimum of 10 experimental units were used. The animals were reared for their whole life cycle, from neonates to their natural death for the following parameters: individual growth, fertility, number of instars and longevity. Whenever accidental deaths and losses occurred it was necessary to replace lost individuals by a new neonate (of a known age) from the stock culture.

In determining the size of the animals body, measurements were made from the top of the head to the end portion of the carapace using an MARK, M-8 microscope with a calibrated eye piece and a magnification of x 40. The measurements were taken to determine the growth curve, which was done using RICHARDS (1959) equation - minimum squares method:

$$Lt = Lmax\ (1-(b)\ e^{(-g(t+to))})^p$$

where: Lt = estimated length relative to age "t" (μm); Lmax = maximum length attained; b = model parameter; g = growth constant; to = curve inflection point (h); p = exponential equal to the reciprocal of "b".

Other parameters measured were: neonatal size; age and size at primipara; total number of boods; fertility (the number of neonatas per batch); number of development stages.

Results

The growth curves obtained with *Scenedesmus quadricauda, Ankistrodesmus gracilis* and *Pediastrum duplex*, with a temperature that oscillates between 26 and 28 °C are presented in figure 1. The growth curves of the organisms fed with each of the three species of algae were similar. With Lmax values of 1191 to 1286 μm the animals continued growing until old age.

The curve inflection point of the curves for *S. quadricauda, A. gracilis* and *P. duplex* gave 34 ± 15, 45 ± 8.8 and 43 ± 16 hours respectively. Indicating that the new born fed with *S. quadricauda* grew faster and obtained the maximum growth observed, compared with the organisms fed with the other two algae, which, presented similar growth.

The neonatas from the primiparas fed with *Pediastrum*, had a greater size 429.84 μm, followed by *Scenedesmus* 423.29 μm and finally the progeny of mothers fed with *Ankistrodesmus* 421.66 μm (Table 1). Even so, these differences were not statistically significant, ($F_{2,131}$ = 0.084; P = 0.919).

A summary of the results obtained for each life history parameter of *M. micrura*, fed with each one of the three algae, is presented in the table 1. The neonatas from the primiparas fed with *Pediastrum*, had a greater size 429 μm, followed by *Scenedesmus* 423 μm and finally the progeny of mothers fed with *Ankistrodesmus* 421 μm. Even so, these differences were not statistically significant, ($F_{2,131}$ = 0.084; P = 0.919).

Primiparas fed with *Scenedesmus, Pediastrum* and *Ankistrodesmus*, presented on average 4.2, 4.5 and 4.2 neonatas respectively. The number of neonatas liberated by the primaparas fed with the three cloroficeas, were not different significantly ($F_{2,27}$ = 1.204; P = 0.315). Individuals fed with *S. quadricauda*, reached sexual maturity with a mean length superior to that obtained by *A. gracilis* and *P. duplex*. ($F_{2,59}$ = 2.105; P = 0.131).

The age of primipara presents no difference significant between different food - algae ($F_{2,63}$ = 0.726; P = 0.488). The mean values with their respective deviants are in table 1.

The Post embryonic development time between the three treatments was not significantly different ($F_{2,63}$ = 1.197; P = 0.309). There was a difference significant ($F_{2,27}$ = 5.222; P = 0.012), between the total number of eggs produced by females fed with the different algae. TUKEY's test showed that the animals fed with *Scenedesmus quadricauda* had on average a smaller number of eggs (53.8), statistically different when compared with the mean number of eggs produced by animals fed with *Ankistrodesmus gracilis* (64.4) and *Pediastrum duplex* (65.4). The mean egg production of *P. duplex* and *A. gracilis* was not statistically different.

Moina micrura when fed with *P. duplex* lays less (7,1) than when fed with *S. quadricauda* and *A. gracilis* (7,3 and 7,4 respectively). There was no difference significant with this item ($F_{2,27}$ = 0.409; P = 0.668).

The number of instars were not different significantly ($F_{2,27}$ = 2.769; P = 0.080).

The length of life of *Moina micrura* fed with *Pediastrum, Scenedesmus* and *Ankistrodesmus* was 242, 257 and 260 hours respectively. Their ages were not different significantly ($F_{2,27}$ = 0.370; P = 0.694).

The body size and the number of eggs relationship in each bath is illustrated in figure 2a, b and c. The linear regressions were statistically significant for the three algal species and they did not differ from each other.

Discussion

Growth

In the present study, the growth curves obtained for *Moina micrura* showed an initial period of exponential growth extending beyond the onset of maturity, reaching an asymptotic adult latter stages irrespective of algae species. According to ROCHA (1983), HERZIG (1984), JAYATUNGA (1986), ROCHA & MATSUMURA-TUNDISI (1990), CARABALLO (1992), this pattern of growth is similar in cladocerans of whether they are tropical or temperate.

According do LYNCH (1980) small sized species of *Daphnia* (< 1 mm) which

mature early, continue to grow after the onset of maturity and in which a large proportion of the energy consumed goes to body growth and a small proportion goes to reproduction.

The results of this study reveal that after maturity the energy channelled toward reproductive growth is greater than that chanalled toward body growth in *Moina micrura*, under non-limiting food conditions and constant temperature. JAYATUNGA (1986) also studing *Moina micrura* under well defined conditions of food and temperature found that the species put the greatest proportion of their growth after maturity into reproduction. Neither of these examples fit into LYNCH's categorisation.

To sum up, even being a small species (0.7 - 1.0 mm mature females) *Moina micrura* tend to invest its energy fairly between growth and reproduction with all the three algae tested.

Fecundity

The present study provides evidence that the only noticeable significant differences were found between the total number of eggs produced by females fed with the different algae, for example, *Moina* produced more eggs when fed with *Pediastrum duplex*, which present a better nutritive level of organic carbon and chlorophyll-a compared with the other two algae food (DÍAZ-CASTRO 1994).

In relation to other life history traits such as: size and number of neonates, size and age of the primipara, post embryonic development, number of broods, number of instars and life span, there were not statistically differences in the responses of *Moina* in the presence of the food algae species.

It is important to point out that Moina did produce eggs throughout its whole life cycle in the experiments, even in latest adult stage. Such a good performance is likely due to the good food conditions (non-limiting), and also that *Moina* in the tropics is a very successful cladoceran, implying that the explotation of its potential for culture practices might support a good harvestable production (AMARANSINGHE et al. 1997, BONOU et al. 1991, HARDY & DUNCAN 1994).

In conclusion, life histories of *Moina micrura*, reported in the literature (Table 2) are still difficult to compare, because they occurred under different environmental conditions: some were carried out in the laboratory, other *in situ*, neither quantity nor quality of the food used was well defined. Comparative experimental studies, with cladocerans such as *Moina micrura*, very common in tropical lakes and reservoirs, should be encouraged to improve our understanding of these key species with respect to position and function in the food webs of tropical waters.

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Table 1: Life history of *Moina micrura* fed with *S. quadricauda, A. gracilis* and *P. duplex.*

ITEM	*Scenedesmus*	*Ankistrodesmus*	*Pediastrum*
Mean new born size (µm)	423 ± 11.28 (47)*	421 ± 10.84 (42)	429 ± 10.64 (45)
Mean size of primipara (µm)	677 ± 20.91 (19)	699 ± 13.08 (23)	697 ± 20.91 (19)
Maximum adult size (µm)	1081	1035	1058
Mean age of primipara (Hours)	39 ± 2.78 (22)	40 ± 3.32 (22)	39 ± 1.71 (22)
Life span (Hours)	257 ± 12.26 (10)	260 ± 11.31 (10)	242 ± 16.86 (10)
Mean number of broods	7.3 (10)	7.4 (10)	7.1 (10)
Mean number of eggs at the first brood	4.2 (10)	4.2 (10)	4.5 (10)
Maximum number of eggs in one batch	16 (10)	16 (10)	16 (10)
Mean production of eggs	53.8 ± 8.6 (10)	65.4 ± 9.9 (10)	64.4 ± 6.3 (10)

* Total number of organisms observed in bracket.

Table 2: Life history of *Moina micrura*, according to various authors.

ITEM	(1)	(2)	(3) AD	(3) SAD	(4)	(5)	(6)	(7)
Size at birth (µm)	*182	465	533	508	-	425	432	420
Size at primipara (µm)	*294	602	846	824	-	691	523	-
Age of primipara (µm)	2	3	1.22	1.21	-	1.65	0.83	-
Maximum adult size (µm)	*400	1008	925	858	1460	958	***792	820
Number of instars	**6	13	4	4	-	10	-	-
Total production of eggs*	10-26	61.8	25.1	10.1	-	61.2	-	26
Life span (days)	14.5	13	4.5	3.2	17	10.54	***6.16	-

(1) MONTU (1975), temperature 20 °C. * valvar carapace length **stages. Laboratory work.
(2) MURUGAN (1975), temperature 28-30 °C. Stages. Laboratory work.
(3) FIM (1992), temperature in manured tanks (AD) 29.96 °C and non manure tanks (NDA) 28.8 °C. Stages. Field work.
(4) ESIPOVA (1969), temperature 18-21 °C. Laboratory work.
(5) Present study, temperature 26-28 °C. Laboratory work.
(6) JAYATUNGA (1986), temperature 27 °C, 1.0 mg C. l^{-1}. ***to 5th adult instar. Laboratory work.
(7) AMARASINGHE et al. (1997), temperature 27.5 °C. Laboratory work.

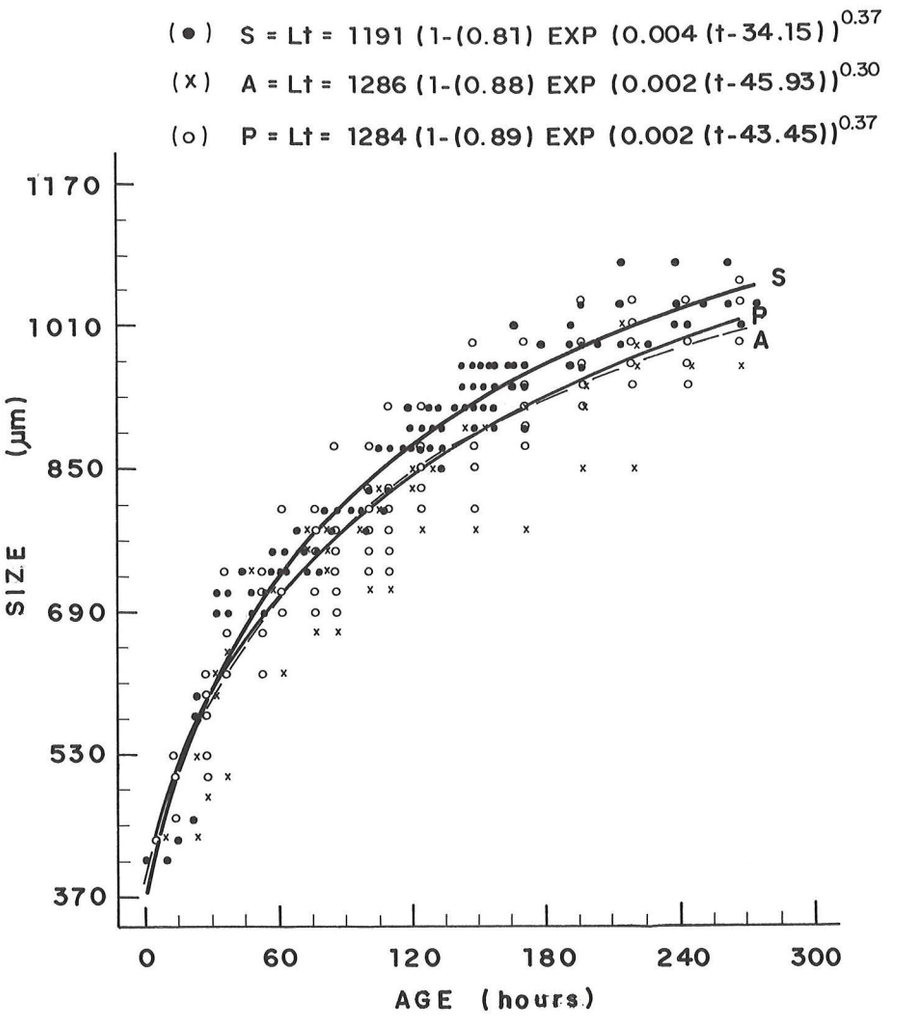

Fig. 1:
Growth curves of *Moina micrura* fed with *P. duplex* (P), *A. gracilis* (A), and *S. quadricauda* (S).

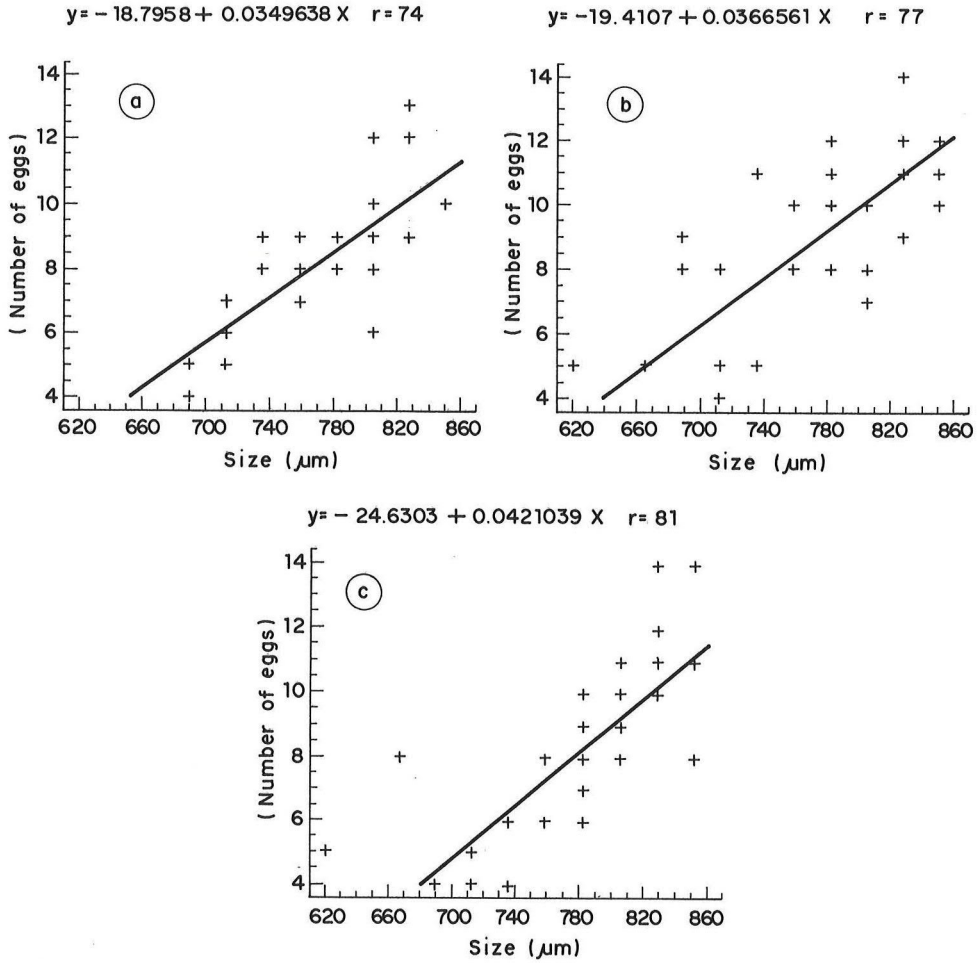

Fig. 2:
Relationship and regression calculated between the size of *Moina micrura* and the number of eggs produced by animals fed with a) *S. quadricauda,* b) *P. duplex*, and c) *A. gracilis*.